

What is claimed is:

- sub 13
1. A method of making an emitter contact for an emitter region of a bipolar transistor, the method comprising:  
forming a polysilicon structure on an emitter region position; and  
substituting metal for at least a portion of the polysilicon structure.
  2. The method of claim 1 further including forming an emitter region at the emitter region position after forming the polysilicon structure.
  3. The method of claim 2 wherein the polysilicon structure includes a doped layer and forming the emitter region comprises outdiffusing dopant from the doped layer to the emitter region position.
  4. The method of claim 1, wherein forming the polysilicon structure on an emitter region position comprises:  
forming a diffusion barrier layer; and  
forming a polysilicon layer on the diffusion barrier layer.
  5. The method of claim 4, wherein the diffusion barrier layer comprises at least one of the following: a silicon carbide, a silicon oxycarbide, and a titanium nitride.
  6. The method of claim 4, wherein the polysilicon layer includes polysilicon and germanium.
  - Sub C2 7. The method of claim 1 wherein substituting metal for the polysilicon structure comprises substituting metal for substantially all of the polysilicon structure.

8. The method of claim 1 wherein substituting metal for at least a portion of the polysilicon structure, comprises:

depositing metal on the polysilicon structure; and  
urging diffusion of the deposited metal into the polysilicon structure.

9. The method of claim 8, wherein urging diffusion of the deposited metal and the polysilicon structure comprises heating the deposited metal and the polysilicon structure.

10. The method of claim 1 wherein substituting metal for at least a portion of the polysilicon structure comprises:

forming a metal layer on the polysilicon structure; and  
heating the metal layer and the polysilicon structure.

11. The method of claim 1 wherein the metal comprises at least one of aluminum, gold, and silver.

12. A method of making an emitter contact for a bipolar transistor, the method comprising:

forming a polysilicon structure on a layer of the transistor, the polysilicon structure including:  
a diffusion barrier layer on the layer; and  
a polysilicon layer on the diffusion barrier layer; and  
substituting metal for at least a portion of the polysilicon layer.

13. The method of claim 12, wherein the polysilicon layer includes a dopant.

14. The method of claim 12, wherein the diffusion barrier layer comprises at least one of the following: a silicon carbide, a silicon oxycarbide, and a titanium nitride, and the polysilicon layer includes polysilicon and germanium.

Subcs) 15. The method of claim 12 wherein substituting metal for the polysilicon layer comprises substituting metal for substantially all of the polysilicon layer.

16. The method of claim 12 wherein substituting metal for at least a portion of the second polysilicon layer, comprises:

depositing metal on the polysilicon layer; and  
heating the deposited metal and the polysilicon layer.

17. The method of claim 12 wherein the metal comprises at least one of aluminum, gold, and silver.

18. A method of making an emitter contact for a bipolar transistor, the method comprising:

forming a polysilicon structure on a layer of the transistor, the polysilicon structure including a doped diffusion barrier layer on the layer and a polysilicon layer on the diffusion barrier layer;  
depositing metal including at least one of aluminum, gold, and silver on the polysilicon layer; and  
heating at least the deposited metal and the polysilicon structure to urge diffusion of the deposited metal into the polysilicon layer.

19. The method of claim 18, wherein the diffusion barrier layer comprises at least one of the following: a silicon carbide, a silicon oxycarbide, and a titanium nitride.

20. A method of making a metal contact for a bipolar transistor, the method comprising:

forming a polysilicon structure on a layer of the transistor; and  
substituting metal for at least a portion of the polysilicon structure.

21. The method of claim 20 further including forming an emitter region in the layer underneath and in contact with the polysilicon structure.

22. The method of claim 21 wherein the polysilicon structure includes a doped layer contacting a region of the layer and forming the emitter region comprises diffusing dopant from the doped layer into the region.

23. A method of making a bipolar transistor having self-aligned base contacts and self-aligned metal emitter contact, the method comprising:

forming first and second polysilicon base contacts on a semiconductive layer, the contacts spaced apart to define an active region in the semiconductive layer;

outdiffusing dopant from the first and second base contacts into the semiconductive layer to form extrinsic base regions aligned with the base contacts;

implanting an intrinsic base region in the active region;

forming a doped polysilicon structure on the intrinsic base region;

forming an emitter region self-aligned with the doped polysilicon structure by outdiffusing dopant from the doped polysilicon structure into the intrinsic base region; and

substituting metal for at least a portion of the polysilicon structure after forming the emitter region, thereby forming a metal emitter contact self-aligned with the emitter region.

24. The method of claim 23:  
 wherein the polysilicon structure includes:  
     a doped diffusion barrier layer on the intrinsic base region; and  
     a polysilicon layer on the doped diffusion barrier layer; and  
 wherein substituting metal for at least a portion of the polysilicon structure  
     includes substituting metal for substantially all of the polysilicon  
     layer.

25. The method of claim 24, wherein the diffusion barrier layer comprises at  
 least one of the following: a silicon carbide, a silicon oxycarbide, and a titanium  
 nitride, and the polysilicon layer includes polysilicon and germanium.

26. The method of claim 24 wherein substituting metal for substantially all of  
 the polysilicon layer comprises:  
     depositing metal on the polysilicon layer; and  
     heating at least the deposited metal and the polysilicon layer to a  
     predetermined temperature.

27. The method of claim 23 wherein the metal comprises at least one of  
 aluminum, gold, and silver.

28. A method of reducing emitter resistance of a bipolar transistor, the method  
 comprising:  
     forming a bipolar transistor structure having a polysilicon emitter contact;  
     substituting metal for at least a portion of the polysilicon emitter contact.

29. A silicon-germanium (SiGe) heterojunction bipolar transistor for RF wireless  
 applications, the transistor comprising:

- a diffusion barrier layer contacting an emitter region and comprising at least one of the following: a silicon carbide, a silicon oxycarbide, and a titanium nitride;
- a metal layer contacting the diffusion barrier layer and comprising at least one of aluminum, gold, and silver; and
- a SiGe base region contacting the emitter region;

30. The SiGe heterojunction bipolar transistor of claim 29 wherein the base region has a graded silicon-germanium  $\text{Si}_{1-x}\text{Ge}_x$  composition, where x varies according to position along a depth dimension of the base region.

31. ~~An integrated memory circuit comprising:~~
- ~~a memory array having a plurality of memory cells;~~
  - ~~an address decoder coupled to the memory cells;~~
  - ~~a plurality of bit lines coupled to the memory cells;~~
  - ~~a voltage-sense-amplifier circuit coupled to the bit lines; and~~
  - ~~wherein at least one of the memory cells and the voltage-sense amplifier circuit includes a bipolar transistor comprising:~~
  - ~~a diffusion barrier layer contacting an emitter region and comprising at least one of the following: a silicon carbide, a silicon oxycarbide, and a titanium nitride; and~~
  - ~~a metal layer contacting the diffusion barrier layer and comprising at least one of aluminum, gold, and silver.~~

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